One-Shot Manufacturing on Large-Scale of 3D Upgraded Panels and Stiffeners for Lightweight Thermoplastic Textile Composite Structures (Large-Scale Integrating Collaborative Projects, Grant Agreement Nº 263159)

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Kontinuirana izrada poboljšanih 3D panela i ukrućivala za lake plastomerne tekstilne kompozitne strukture (FP7-NMP-2010-3,4-1 LARGE)

MAPICC 3D *je četverogodišnji europski projekt* Sedmoga okvirnog programa FP7 *(e.* Seventh Framework Programme *) usmjeren na proizvodnju tekstila i kompozita na temelju plastomernih materijala. Cilj je razviti predoblike direktno, izbjegavajući sve korake povezivanja da bi se smanjila masa konačnih struktura. Potpuno automatizirani i visoko prilagodljivi tehnološki procesi trebaju osigurati pouzdanu brzinu proizvodnje materijala od 5 do 20 minuta po m², ovisno o složenosti tekstilne strukture. Inovacija je razvoj kompozita pogodnih za proizvođače opreme (e.* original equipment manufacturer*, OEM) u industriji prijevoznih sredstava, građevini i proizvodnji energije, koji mogu zamijeniti metalne konstrukcije.*

MAPICC 3D is large-scale integrating collaborative project funded under the *7th Framework Programme* focused on the development of industrial processes for on-line automatic production of 3D textile composite structures. The goal is to develop innovative methods for textiles and thermoplastic composite materials produced for industrial vehicles (automobiles, railways, planes). The project coordinator (01/12/2011-30/11/2015) is *Ecole Nationale Supérieure des Arts et Industries Textiles*, *ENSAIT*, Roubaix, France. The project partners are universities, research centres and industrial partners from nine European countries.

Fully automated and highly adaptable processes should ensure highly reliable production rate comprised between 5 and 20 minutes per m², depending on the complexity of textile structure. Reduction in manufacturing costs is expected compared to the current products by improving the productivity by 38% and 14% less needed time until it can reach the market. The project partners have been chosen on the basis of complementarity and high level of expertise in the field of textiles, mechanics, modelling and characterization of final products. Industrial partners will achieve greater market share in different sectors and market competitiveness with the development of innovative composites, processes, simulation tools, procedures and appropriate equipment.

The management project structure is arranged according to the size and the nature of the consortium, the strategic and operational levels are closely related, and all the partners were presented to the *European Commission*.

MAPICC 3D project work-plan

The demand of energy efficient eco-vehicles is increased, due to the fact that such vehicles are lightweight, reliable and economical with less energy consumption, minimum CO_2 emission, and possibility of recycling at the end of their lifecycle. Using of particular plastic and reinforced plastic for lightweight vehicles can implement many requirements. Lighter and cheaper parts require redesign of the existing parts in order to take full benefits of composite material by higher integration, reduction of installation costs and final vehicle weight.

MAPPIC 3D project access offers to manufacturers a new working concept, and the research is conducted through eight work packages (WP0-WP7) for on-line automatic composite production.

TABLE 1 – *MAPICC 3D* project partners

Partner	Partner Name		Country
University / Research Center	*ENSAIT*	*Ecole Nationale Supérieure des Arts et Industries Textiles*	France
	ARMINES	*Association pour la Recherche et le Développement des Méthodes et Processus Industriels*	France
	POLIMI	*Politecnico di Milano*	Italy
	RTU	*Rīgas Tehniskā Universitāte*	Latvia
	TUD	*Technische Universität Dresden*	Germany
	TTF	*Sveučilište u Zagrebu, Tekstilno-tehnološki fakultet*	Croatia
Industry	*Alstom Transport SA*		Spain
	Association Aria		France
	Coexpair S. A		Belgium
	Dylco		France
	Engineering System International GmbH		Germany
	ESI Group		France
	Latvijas Finieris		Latvia
	Mecacorp		France
	Reden		The Netherlands
	Steiger		Switzerland
	Tencate Corporate Technologies		The Netherlands
	Volvo Truck		Germany

Automation, fewer steps in the production and logistics reduce the final costs up to 33% compared to current 2D methods.

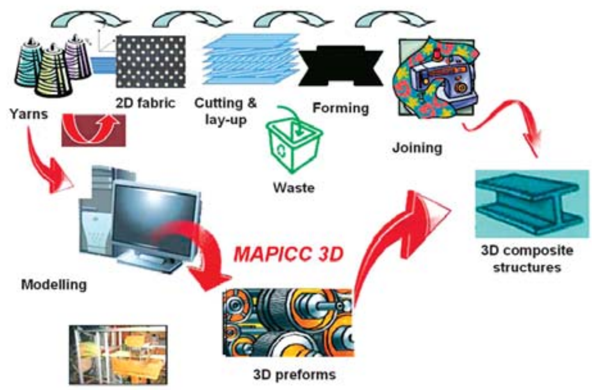

FIGURE 1 – *MAPICC 3D* production compared with conventional methods

MAPICC 3D project goals and tasks

The project goal is the development of new automated and cost-effective processes for the production of multifunctional lightweight porous thermoplastic composites. The advantage of the project is the production of 3D preforms directly, the ability to predict the final composite structure properties, the possibility of installing quality sensors, pipes or wires, production of curved panels and beams with complex high-quality intersections, high flexibility of design and small number of manual operations.

The main project tasks are the following:
- development of new textile technologies able to produce 3D fibre structures with tailored yarn paths to improve mechanical properties of composite parts;
- development of virtual tools able to display all yarn geometry types and their development during the manufacturing process, which can model 3D structure and predict the mechanical behaviour of final composites according to the textile architecture and the resin choice;
- development of numerical simulation that can describe the thermo-mechanical consolidation process using network technologies (*meshfree techniques*) within the same software environment for the calculation of 3D textile manufacturing processes;
- improvement of the level of security and quality of composite structures by dynamically controlling the structure state during the lifecycle;
- production of lightweight composites by the development of new technologies and fibre management in three directions for 3D preforms: panels and stiffeners;
- development of complex 3D preforms: O, U, T, I, L, S (with respect to the possibility of yarn relocation in three directions, combination of three previously tested methods of combining yarns allows the realization of more complicated form of X, Y, Π);
- development of procedures and equipment needed to obtain textile structures for rectilinear or curved stiffeners with 3D fibre development based on multi-axial knitting technology which can interlace carbon, glass or thermoplastic fibres;
- development of procedures for stiffener production in a whole range of Y or X profiles;
- production of three surface layer spacer fabrics: U (face to face), U (zig-zag) and X shaped, such fabrics are expected to be efficient for energy absorption in components associated with impact (*crash-related components*).

Simulation tools are used to test new process parameters controlling the kinematics of the proposed procedure and the whole process is simulated on small components. From the obtained 3D geometry the mechanical properties are determined by the virtual mechanical tests on the test bodies obtained by the thermo-mechanical distortion effects. Mechanical properties of hybrid yarns, including glass fibres and thermoplastic materials are sufficient to verify mechanical standards of preforms, and the ability of applying technological processes in transport and civil engineering. The proposed models of research partner *Armines* will be used during the project for the consolidation processes and for the welding process of thermoplastic materials. The consortium will study the relationship between the yarns, production conditions, microstructure of 3D preforms and useful properties of the composite products.

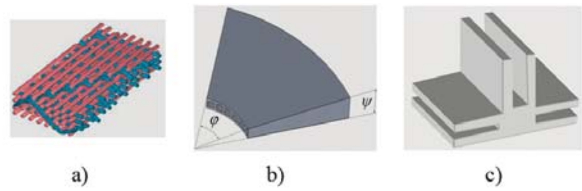

FIGURE 2 – a - 3D textile structure, b - *MAPICC 3D* virtual concept of panel, c - *MAPICC 3D* virtual concept of stiffener

Scientific Research at the Faculty of Textile Technology, Zagreb

A group of researchers from the Institute for *Textile Chemistry and Ecology, Faculty of Textile Technology* (*TTF*), *University of Zagreb*, is included in the *MAPICC 3D* project and the *TTF* coordinator is Professor Ana Marija Grancarić.

The main tasks of the *TTF* are the following:
- characterization of 3D textile structures and preforms for modelling process evaluation;
- testing the impact of recycled fibres on the final structure of 3D preforms;
- consideration of the sensors embedded in preforms and resin effectiveness for the implementation of improved properties;
- mechanical, electrical and electromechanical characterization of produced fibres;
- study of the relationship of properties of fibres, yarns and final preform structures;
- development of a system for structure monitoring within the composites or on its surface and evaluation of properties of smart preforms.

Faculty of Chemical Engineering and Technology, Department of Surface Engineering and Polymer Materials, University of Zagreb, is included as Croatian partner of the TTF in this project where some testing will be made within the project tasks.

Dissemination of the project results will be realized through seminars, consortium meetings, conferences, presentations at conferences, brochures, scientific journals and on the web-site of the *MAPICC 3D* project-mapicc3d.ensait.fr.

MAPICC 3D project will result in the exchange of knowledge, production procedures and tested methods which will be applied in the economic sector. The main project innovation is the direct production of 3D preforms: panels and stiffeners. Innovative procedures can enable the improvement of tensile properties of the composites, their flexibility and compression. Furthermore, the economic criteria are important in the development of computer software, manufacturing equipment, textile fibres, and manufacturing procedures. The project should allow the production of high quality composite structures at competitive price for the European market and other markets as well.

Acknowledgements

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